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Gender difference in Achilles tendon length by resting angle measurement in correlation to body parameters between Egyptian physical therapy students

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ABSTRACT

Aim of the study: our study aims to report if there is a gender difference in length of the Achilles tendon by measuring achilles tendon rest angle in relation to body parameters of the physical therapy students as adult samples.

Methods: Measuring the resting angle of the Achilles tendon by goniometer for 134 students (106) male students and (28) female students and correlate with age, gender, body height, weight. **Results:** the mean Achilles tendon resting angle in male students 21.54° , SEM 3.27° and female students 22.42° SEM 2.83° with a total of 21.73° SEM 3.20° respectively, the tendon length correlates with the male student's height mean (172.18 ± 8.29) and female students height (164.89 ± 7.65) with total (170.66 ± 8.66) respectively with higher correlation in the female students (0.637) than male students (0.383). On other hand, there is no correlation to age, weight with male students (72.15 ± 11.18) and female students (72.57 ± 14.13) with a total (72.23 ± 11.80) respectively. **Conclusions:** there is a gender difference in achilles tendon length in relation to height with more correlation in females than males in the age of the adulthood.

Keywords: Gender, achilles tendon, Achilles tendon resting angle, physical therapy students.

1. INTRODUCTION

The tendon of Achilles has considered one of the most powerful tendons in the body; it is formed fibrous tissue connecting plantar flexor muscles to calcaneus bone (Doral et al., 2010). The Tendon of Achilles has a special elastic force facilitating its stretch during walking running, jumping, and standing on tip-toe (Kubo et al., 2015). A lot of the previous studies discussed Achilles'

tendon stretch force which varies from 5000N during one-legged jumping (Lichtwark & Wilson, 2007) to 9000N at running (Komi et al., 1992). Despite of the high capability of the tendon to resist 1000 pounds of force, it is vulnerable to injury which varies from irritation to partial tear even a full tear of the tendon (Kakouris et al., 2021). Achilles tendonitis is a common clinical complaint in the region of ankle and foot, especially in men, so many studies reported that the frequency of tendon Achilles' rupture between men and women ranges from 2:1 to 19:1 (Carden et al., 1987). Bryant et al., (2008) explain frequent exposure of men to inflammation of the tendon of Achilles even to rupture of more than women due to physiological variation between both genders. Estrogen secretion in the female can enhance collagen formation which maintains the strain of the tendon of Achilles.

Other studies reported that the toughness in the tendon of achilles is greater in males than females (Fouré et al., 2012). Which gives another explanation for the frequent injury of tendon of achilles in the male (Vosseller et al., 2013). Mainly this difference between males and females in Achilles tendon properties is attributed to the body parameters (Nyström & Holmlund, 1983). The large body mass requires strong weight-bearing tendons that have special adaptation in their length to transfer high load. Thus, lead to an increase in tendon stiffness (O'Brien et al., 2010). There are changes in the stiffness of the tendon of the Achilles according to the age as it increases from the 9 years age to adulthood in humans (Bayer et al., 2010). These findings were confirmed by research studies on laboratory animals (Shadwick, 1999). The increase in toughness of the Achilles tendon results to increase in body mass index (O'Brien et al., 2010). As the body mass index increases with the age prepare the Achilles tendon to afford higher loads (Malina & Bouchard, 1991). So in our study, we chose the adulthood period to study the correlation of body parameters about the length of the Achilles tendon and its physiological difference between males and females.

There are several methods in measuring the length of the tendon of Achilles starting from direct injection of radio-opaque markers in the substance of the tendon (Kangas et al., 2007). To use ultrasound (Suydam et al., 2013) or computed tomography (Rosso et al., 2012). But we need an easily applicable, non-invasive, more accurate method to measure the length of the tendon of achilles (Barfod, 2014). As the arch of the movement of the ankle joint helps us an indirect method for Achilles tendon length measurement. Each 10 millimetres elongation of the tendon of achilles results in a 10° of increase in the ankle dorsiflexion (Costa et al., 2006). The ankle joint resting position is called resting angle of Achilles tendon (Carmont et al., 2013). This angle changes after rupture of the tendon of achilles can be used to follow up the repair and rehabilitation.

This study had an objective: to measure the tendon of achilles length by simple method (ATRA) for students of faculty of physical therapy Delta University as a sample of adulthood and correlate it with student parameters like gender, age, body length, and body weight.

2. MATERIAL & METHODS

Participants

A total of one hundred thirty-four (134) physical therapy students participate in our study, with One hundred and six healthy male students with a percent (79%) and twenty-eight healthy female students with a percent (20.9%) (table 1) from the faculty of physical therapy, kafrelsheikh university, Egypt with regular physical exercise randomly selected to participate in our study which was performed from July 2021 to December 2021. With Inclusion criteria, age 18-22 years, our students are aware enough able to speak and understand our orders. The exclusion criteria were: (A) all the students which participates in the study and suffering from injuries in the lower limb within the previous 6 months (B) all the students which have a previous history from injury in achilles tendon and neurological diseases: (C) all the students which participated any sporting event and vigorous activities criteria which done by (Holler et al., 2019). All the students were forbidden from any heavy exercise 24 hours before the test. All the students wrote consent about the measurement, and our study was approved by the Ethical Committee of Faculty of Physical Therapy Medicine, kafrelsheikh University, Egypt. Ethical approval cod (P.T/BAS/8/2021/19).

Table 1 Gender information's about the students

Sex	No	%
Male	106	79.1%
Female	28	20.9%

Measurement of ATRA (Achilles tendon resting angle)

The Achilles tendon resting angle of the participated students was measured by two expert examiners one measuring the tendon and another recording the data. The method of measuring the tendon was described by Carmont et al., (2013) who stated that the student will be in a prone position with its knee joint in a flexed position at 90°. We ask the participated students to relax their

ankles and feet. We well use in our study goniometer standard with 28 increments (Medi GmbH, Bayreuth, Germany), the goniometer has two arms one of both parallel to the fibula shaft towards the center of the head of the fibula the second arm parallel to the fifth metatarsal bone head, to ensure the right place of goniometer we palpate the center of the fibular head as shown in the (Figure 1A, B).

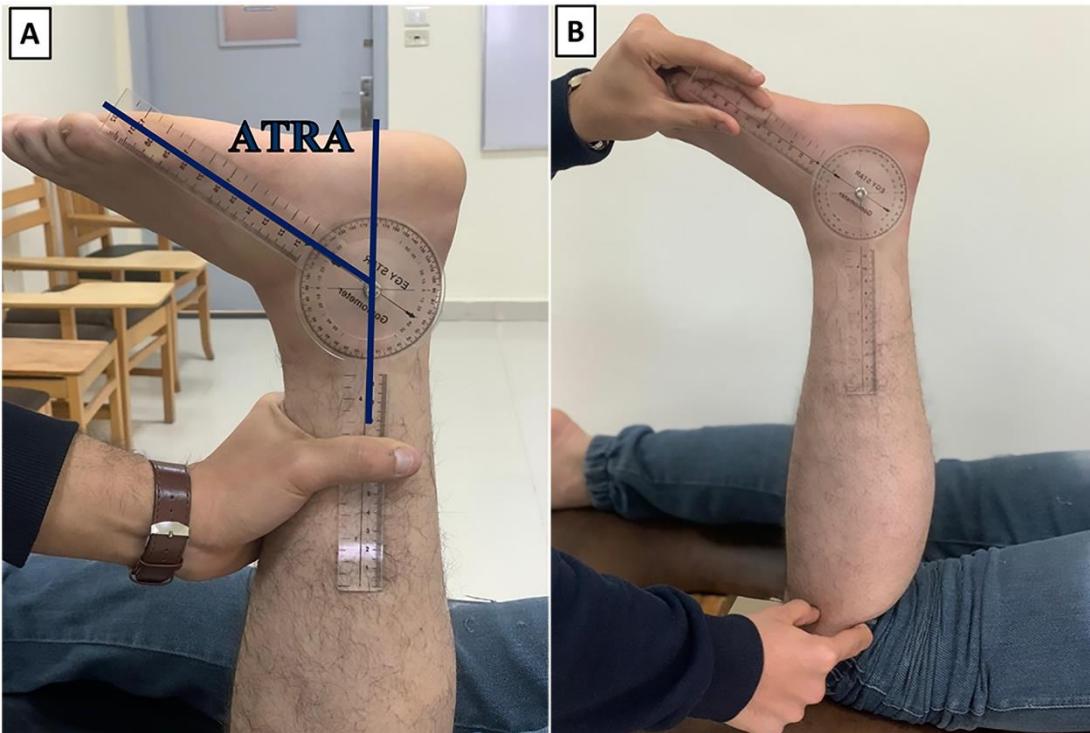


Figure (1A, B) showing the method of measurement of the resting angle of the Achilles tendon

Statistical analysis

Our study data collected analyzed (SPSS) program for Windows (Standard version 22) presented as mean \pm SD (standard deviation). Firstly we check normality and log normality by Kolmogorov-Smirnov test. The variation between the two students groups was compared with the Student t-test. Pearson correlation was used to correlate continuous data.

Level of significance

The variation between the two groups is expressed by (p-value). The results were considered:

Non- significant when ($p > 0.05$)

There is significance between the two groups when ($p \leq 0.05$).

Highly significant between the two groups when ($p \leq 0.001$).

3. RESULT

In our study, a total of 134 students were involved in our study, 106 male students represent (79.1%) and 28 female students represent (20.9%) with a median age of 20.67 (range from 18-24 years).

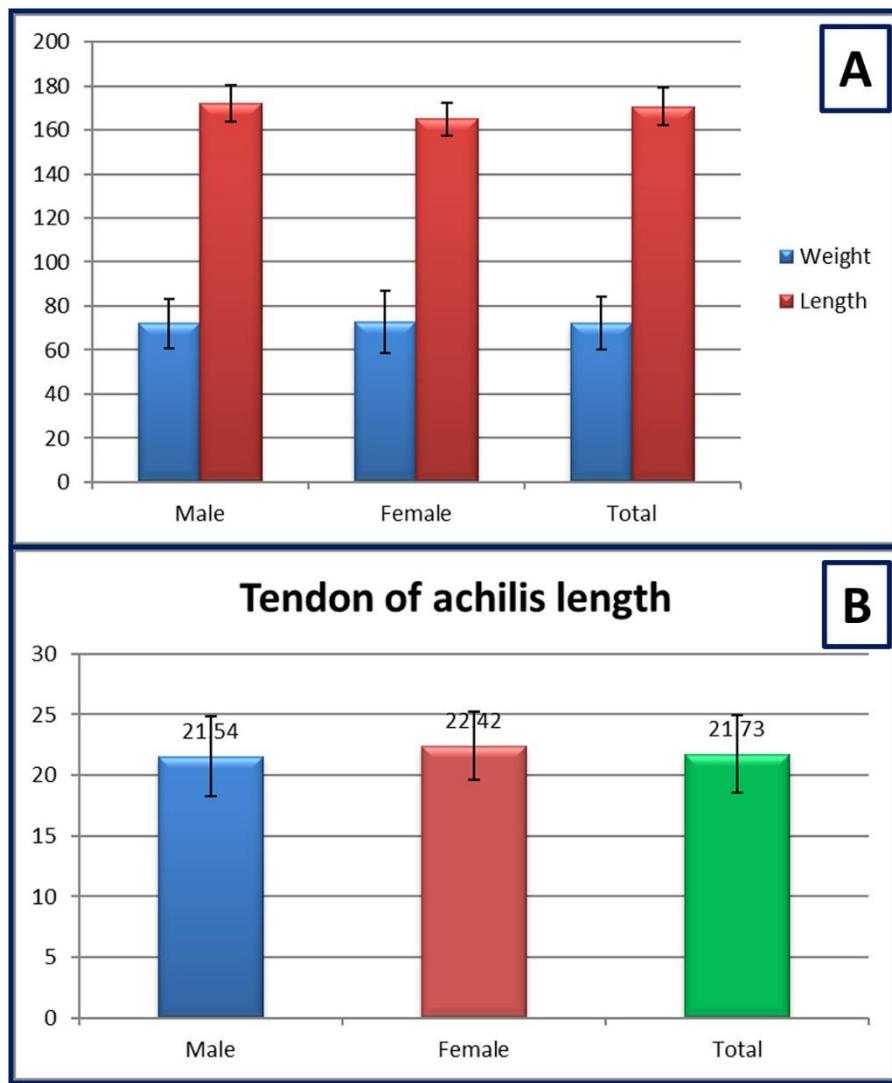
Gender difference regarding student age, weight, length, and length of Achilles tendon

For the students with regular exercise habits as shown in (Table 2) and (Figure 2A, B) there are no significant differences between male students and female students regarding to the age, students weight, and tendon of Achilles resting angle while the students length difference between participant females and males students was statistically higher in male students ($P<0.001$) than female students.

Table 2 Comparison between participant females and males students regarding age, weight, length, and (ATRA) indicator Achilles tendon length

Items	Male (n=106)	Female (n=28)	Total (n=134)	t-test	p-value
Age	20.66±1.39	20.71±1.51	20.67±1.41	0.14	0.88
Weight	72.15±11.18	72.57±14.13	72.23±11.80	0.16	0.86
Length	172.18±8.29	164.89±7.65	170.66±8.66	4.20	<0.001**
ATRA	21.54° SD 3.27	22.42° SD 2.83	21.73° SD 3.20	1.29	0.19

ATRA: Achilles tendon resting angle; SD: standard Deviation. All the above table data were expressed as mean ± SD. ***p < 0.001, **p < 0.01 and *p < 0.05 significant.

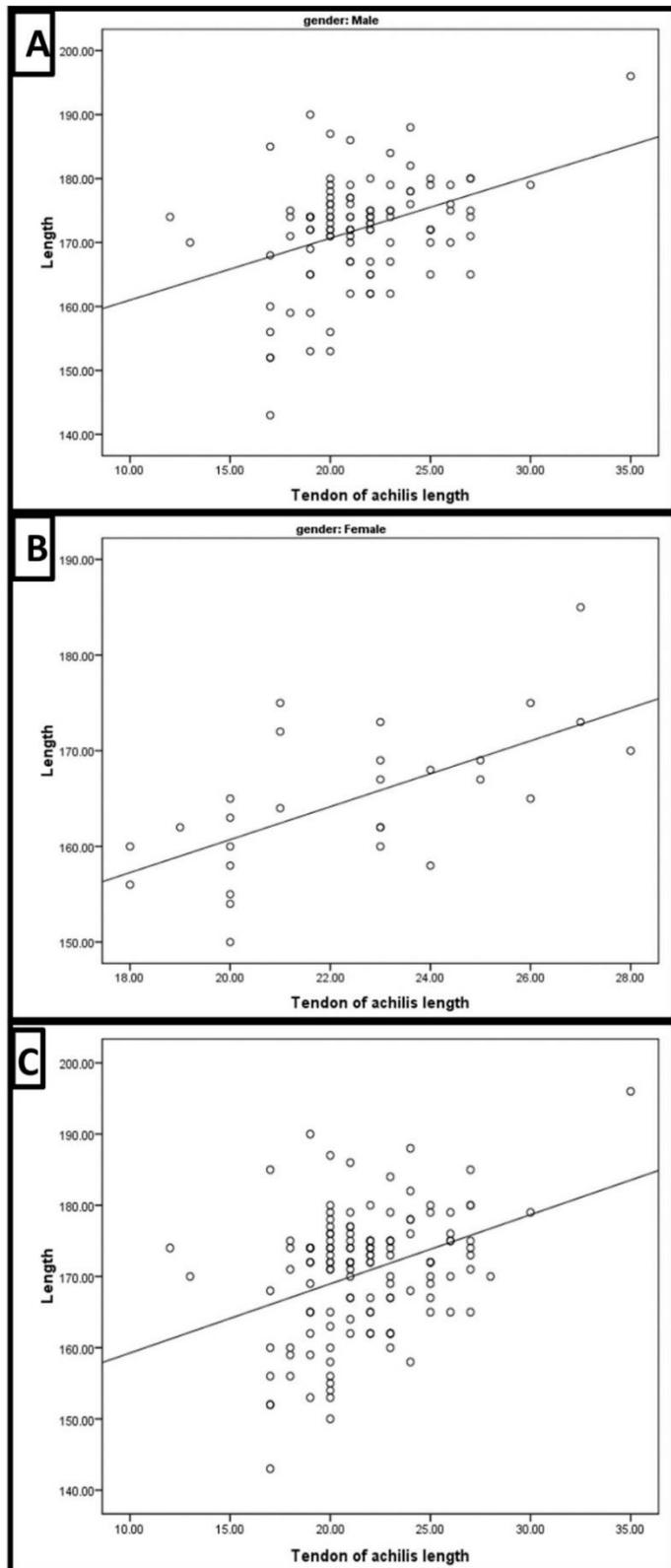
**Figure (2A, B)** Comparison between participant females and males students regarding age, weight, length, and (ATRA) indicator Achilles tendon length

Correlation between the Achilles tendon lengths about the length of students

As shown in (Table 3) and (Figure 3A, B, C) there is a positive correlation between tendon of achilles length and the length of male and female students r (0.383, 0.637, 0.359) respectively and ($P<0.001$) this means that achilles tendon length positively correlated to the length of students but not affected by the weight of the students, also we founded that this correlation between the tendon of achilles length and the length of students is higher in the female students (0.637) than male students (0.383).

Table 3 Correlation between Tendon of Achilles length and other parameters

Items	Male (n=106)		Female (n=28)		Total (n=134)	
	r	p	r	p	r	p
Age	0.12	0.19	-0.13	0.49	0.07	0.37
Weight	0.03	0.74	0.09	0.64	0.04	0.60
Length	0.383	<.001**	0.637	<.001**	0.359	<.001**

**Figure 3A, B, C** Correlation between Tendon of Achilles length and other parameters

4. DISCUSSION

The Achilles tendon is necessary for the normal gait as it is very important in calf muscle contraction reaching its maximum length (Rosso et al., 2015). Achilles tendon rupture is a very serious clinical problem between sports, with the incidence of 10 to 20 per 100 000 per year only in the United States (Leppilahti et al., 1996). We are the first to study the gender difference in achilles tendon length in correlation to body parameters for students of faculty of physical therapy by using resting angle as a simple non-invasive method for Achilles tendon measurements as an adult healthy sample, our study results showed two principal facts when studying the comparison between male students and female students (A). There is no significance between female students and male regarding age, weight, and Achilles tendon length while the student's length was more significant in male than females (B). There is a significance between the length of the tendon of achilles and the length of the participant students which is more obvious in females than males, on the controversy, no significance between the tendon of achilles length and either the age and weight of the students.

As regards the study done by Shultz et al., (2004) how stated that the tissue of the achilles tendon is affected by the sex hormones estrogen and progesterone so the female students who participate in our study, not to menstruation or married and take oral contraceptive pills, thus we remove the hormonal effect which may influence our study. Also, there are different measuring methods for achilles tendon length Pang & Ying, (2006) the first ones who measure the achilles tendon length by using ultrasound as it measures the length of the tendon of achilles from its attachment to calcaneus bone to its junction to gastrocnemius muscle. Rosso et al., (2012) measure the Achilles tendon length by MRI and making a formula in measurement about tibia length which is measured by x-ray (anteroposterior view).

Despite this different method of measurement, we chose resting angle in measurement which is the simplest most applicable, and non-invasive method in measuring the tendon of achilles length, also it is a highly accurate indicator for the length of the Achilles tendon, despite the exposure of the tendon to tension either from plantar flexion movement produced by gastro-soleus complex or dorsiflexion movement of anterior compartment muscles mainly tibialis anterior muscle. The range of motion created at the ankle joint either plantar or dorsiflexion will affect the accuracy of the measurement of the tendon length (Magnusson, 1998). So, the resting angle gives accuracy for the actual tendon of achilles length and uses it to differentiate between female and male participant students and correlate it with body parameters.

In our study, there is no significance in the tendon of achilles length between male students and female students these findings disagree with Zhang et al., (2021) how to perform a study on 30 participants (15 female participants and 15 male participants) and he found that male participants had a longer tendon of achilles length, thickness and cross-sectional area than females participants. Also Deng et al., (2021) reported that there are great differences between male and female Asian adults in architectural properties and tendon of achilles length as male greater than female. The contrast between our findings and others may be due to changes in the methods of measurements of the tendon as in our study we measure with resting angle, while other previous studies measure the tendon of achilles length by ultrasound, but until this time no studies are comparing tendon of achilles length between both gender by using resting angle as a method of measurement.

Our study improved that there is a significant correlation between the tendon of achilles length and the height of the students this finding is consistent with Rosso et al., (2012) who stated that the height of the participants was a significant indicator for Achilles tendon length with an increase of 20.1 mm every 10 cm increase in the body height and no significance in body weight. In contrast to our study, Pang & Ying (2006) did not find a significance between the tendon of achilles length and the body height of the participants, at the same time we found a positive significance between the length of Achilles tendon and student length there is more correlation in females students than males, there is no definite explanation for this finding so it may be the core of further studies in the future.

One strength of our study was to use resting angle measurement as a non-invasive, clinically simple applicable method to study gender differences in the achilles tendon length and its correlation to body parameters and can apply it in different age levels to give more information about the tendon of Achilles as one of the important weight-bearing tendons in our body and more vulnerable to injury.

A limitation of this study was that (A) The variation between examiner skills in measuring the resting angle of the tendon of achilles may exhibit some variations in the mean and standard deviation of the Achilles tendon length (B) both male and female students have no significant variation in the body weight (C) The examiner must be sure that student knee joint in full flexion situation 90 degrees to obtain more acute resting angle.

5. CONCLUSION

The tendon of achilles resting angle is a simple non-invasive measuring method that differentiates gender differences between Achilles tendon length and body parameters of the students, with significance between the Achilles tendon and the length of students with more correlation in females than males.

Acknowledgments

The authors declare no external financial assistance with the project.

Ethical Approval

The study was conducted according to the guidelines of the Declaration of Helsinki approved by the Ethics Review Committee of Scientific Research in the Faculty of Physical Therapy Medicine, kafrelsheikh University, Egypt. Ethical approval cod (P.T/BAS/8/2021/19).

Author's contributions

Dr. Taha: concept and design of the study, clinical studies, and supervision of the study.

Dr. Alghamdi: manuscript preparation and literature search, and critical and final revision as well as final editing of the manuscript.

Dr. Abo Gazya: concept and design of the study, manuscript preparation and literature search, data acquisition and carried out the initial and statistical analyses.

Dr. Sonpol: manuscript preparation and literature search, data acquisition.

Dr. Al-Kushi, Dr. Ibrahim: data collection, clinical studies, and revised the manuscript.

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Conflicts of interest

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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